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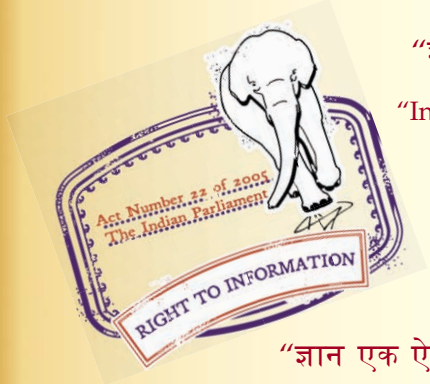

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"Knowledge is such a treasure which cannot be stolen"

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(Reaffirmed 2004)

IS : 7114-1973

Indian Standard

CRITERIA FOR HYDRAULIC DESIGN OF CROSS REGULATORS FOR CANALS

(Fourth Reprint AUGUST 1993)

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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June 1974

Indian Standard

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CRITERIA FOR HYDRAULIC DESIGN OF CROSS REGULATORS FOR CANALS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 22 September 1973, after the draft finalized by the Canals and Canal Linings Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Cross regulator is a structure constructed across a canal provided with arrangements to regulate the discharge for the following purposes:

a) To feed offtaking canals in low supplies;
b) To escape water from canals in conjunction with escapes;
c) To control water surface slope in conjunction with falls, for bringing the canals to regime slope and section;
d) To divert supplies to other canals or part of the same canal to enable repairs and construction work;
e) To control discharge at an outfall of canal into another canal or lake; and
f) To ensure safety of canal lining where subsoil water levels are high.

0.2.1 Cross regulators may be combined with bridges and falls from economic or any other special considerations. When the available working head in an offtaking canal is more than half the full supply depth in the parent canal, cross regulators may not generally be provided in conjunction with head regulators. The structural design of the cross regulator has to be closely co-ordinated with that of the head regulator of offtake when built in conjunction with the same.

0.3 This standard covers the criteria for hydraulic design and important structural details of cross regulators on canals as distinct from weirs and barrages constructed across rivers. The criteria for hydraulic design of barrages and weirs are given in "Indian Standard criteria for hydraulic design of barrages and weirs' (*under preparation*).

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Since published as IS : 6966-1973

†Rules for rounding off numercial values (*revised*).

1. SCOPE

1.1 This standard covers the criteria for hydraulic design of cross regulators for canals.

1.1.1 This standard also covers the design criteria for regulators combined with falls.

1.1.2 Although a cross regulator may be combined with a bridge, this standard does not cover the details of the piers, abutments and bridge decking for vehicular traffic.

2. WATERWAY

2.1 The linear waterway to be provided for the cross regulator should be according to **2.1.1** to **2.1.3.**

NOTE — Marginal adjustments in the waterway may be made to suit the gates of standard size and/or flash boards for regulation.

2.1.1 For an headless regulator (that is, when there is no fall between upstream and downstream full supply levels) in an unlined canal the overall linear waterway may be kept equal to the bed width in case of shallow and wide canals (for example, irrigation canals) and equal to the mean width of the canal in the case of canals with deep and narrow sections (for example, drains) to avoid undesirable constriction and concentration of discharge.

2.1.2 For headless regulator on lined canal the clear linear waterway may be kept equal to the average width of the canal and overall linear waterway equal to width of the canal at full supply level with marginal adjustments in both.

2.1.3 Where the regulator is combined with a fall the clear linear waterway would depend on the following two conditions:

a) For submerged falls, the drawing ratio (that is, the ratio of tailwater over crest to head water over crest) should be greater than 0·8; and

b) For free falls, the discharge per unit length over the crest should be equal to or greater than that required for the available loss of head and the required value of the full supply depth downstream (generally above downstream bed level or above downstream cistern in certain cases).

The value of fluming ratio B_t/B (that is, ratio of clear waterway to design bed width downstream) obtained from Fig. 1 would generally be found to ensure the above two conditions and should not be kept less than 0·5 although it has to be fixed keeping in view the requirements of setting the crest in accordance with **3.1.2.**

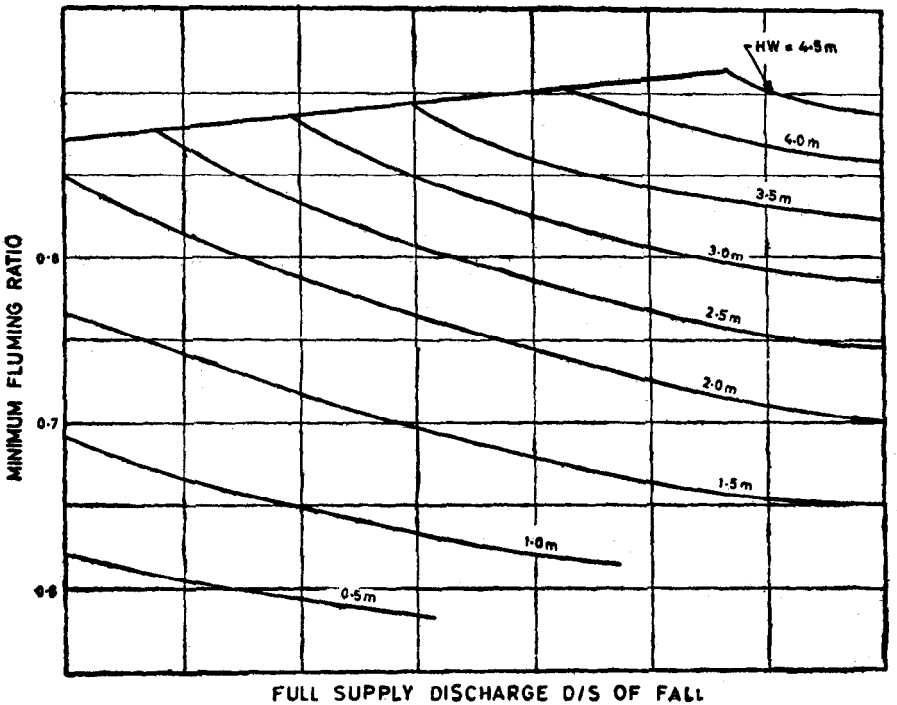

FIG. 1 FLUMING RATIOS FOR FALLS COMBINED WITH REGULATORS

2.1.3.1 In case of falls where modular working (accompanied by formation of distinct hydraulic jump or standing wave) cannot be ensured due to small working heads, the dimensions of waterway should be judiciously selected to allow passage of discharge at subcritical velocities.

2.2 Number and Width of Bays

2.2.1 The number of bays in a canal may be kept odd from aesthetic reasons and to avoid a pier in the centre of the canal where the concentration of discharge and consequently the scour may be somewhat more. This would also help in better check over the centre line of the canal because of direct visibility. In special cases, however, the number of bays may be kept even.

2.2.1.1 The width of each bay for *Karrie* regulation should generally be kept equal to or less than 2·5 m but in no case more than 3 m.

2.2.1.2 For needle regulation the width of each bay may generally be kept between 3 and 6 m.

2.2.1.3 For depths of flow greater than 2 m, gate regulation is adopted. The width of each bay for gate regulation should be kept in accordance with standard sizes of gates, which are readily available or can conveniently be manufactured without much loss of time and effort.

3. CREST LEVEL

3.1 In the case of unlined canals only a sill is provided. In the case of lined canals a crest is generally provided to reduce the height of regulation arrangement. The crest level shall be fixed according to **3.1.1** and **3.1.2**.

3.1.1 The crest level of the cross regulator combined with fall shall be worked out using the following equation:

$$Q = C B_t H^{3/2}$$

where

Q = full supply discharge in m^3/s,

C = coefficient of discharge,

B_t = clear waterway in m, and

H = head over crest = full supply level upstream + head due to velocity of approach (h_a) − crest level.

NOTE — In the above formula the exact value of C, the coefficient of discharge depends on many factors, such as the head over the sill shape and width of the crest, its height over the upstream floor and roughness of its surface. It is, therefore, recommended that the value of C be determined by model studies where values based on prototype observations on similar structures are not available.

3.1.2 In a lined canal, setting of the crest above bed (upstream or downstream, whichever is higher), should not be less than 15 cm nor higher than 40 percent of the normal depth of the canal upstream and fluming ratio calculated according to **2.1.3** may be adjusted accordingly.

3.2 The crest profile (that is, upstream glacis, crest, downstream glacis and the radii joining the upstream and downstream glacis with the crest) should be kept in accordance with requirements for a fall.

3.2.1 Generally for discharges higher than 10 cumecs the upstream and downstream glacis should have a slope of the two horizontal to one vertical. The crest width shall be fixed from operational cosiderations subject to a minimum of 2/3 H (where H is the head over crest). The radius joining the crest with upstream glacis should be kept equal to H and the radius joining the crest with downstream glacis should be kept equal to 1·5 H.

3.2.2 For discharges lower than 10 cumecs the slope of downstream glacis shall be kept at 2·5:1. The upstream glacis should be entirely of

a circular curve without any straight portion. The radius of the circular curve is obtained from the following formula:

$$R_a = \frac{3H^3 - x^2}{2x}$$

where

R_a = radius of curvature of upstream glacis in cm,
H = head over crest in m, and
x = height of crest above upstream bed in m.

The curve joining the crest with the downstream glacis should have a radius of 60 cm.

4. HEAD LOSS

4.1 The loss of head due to expansion and contraction depends on the type of transitions provided. The following general guidelines for calculating this loss shall be adopted:

a) When the transitions are smooth the loss is zero at the inlet and '0·5 × change in velocity head' at the exit, and

b) When the transitions are abrupt the loss is '0·5 × change in velocity head' at the inlet and '1·5 × change in velocity head' at the exit.

4.2 The losses of head in the structure due to friction are negligible and need not be computed.

5. CISTERN DIMENSIONS

5.1 Length of downstream cistern should be such as to absorb the turbulent flow downstream of the hydraulic jump and shall be determined according to the procedure given in IS : 4997-1968*.

5.2 The elevation of cistern floor with respect to crest level shall be determined according to the procedure given in IS : 4997-1968*.

6. EXIT GRADIENT AND UPLIFT PRESSURE

6.1 The structure should be checked for safe exit gradient in accordance with accepted theories and adequate length of floor and downstream cut off wall should be provided for safe values of exit gradients. An exit gradient of 0·2 to 0·3, depending on type of soil and importance of structure, may be considered safe for ordinary conditions. If the overall length of impervious floor is inadequate, the downstream curtain wall has to be deepened to the required extent.

*Criteria for design of hydraulic jump type stilling basins with horizontal and sloping apron.

6.2 The thickness of floors provided shall be sufficient to resist uplift pressures calculated in accordance with accepted theories.

6.2.1 The uplift pressures should be worked out for the following two conditions and the calculation of floor thickness shall be based on the higher value of uplift pressure:

a) When the upstream water level is headed up to full supply level and downstream cistern is pumped dry.
b) When the upstream water level is headed up to full supply level and varying discharges pass downstream.

NOTE — The maximum uplift would occur at the point where the trough of the standing wave is located.

6.2.2 In case the subsoil water level is higher than the full supply level upstream, special precautions should be taken against uplift.

6.2.3 Pressure relief arrangements should be provided in the case of important structures subjected to high uplift pressures. When these arrangements are provided suitable reduction in uplift pressures may be provided depending upon the soil and the effectiveness and expected performance of the relief measures provided.

7. OTHER REQUIREMENTS

7.1 The upstream and downstream approaches should be smooth and should generally conform to the requirements for falls.

7.2 The upstream and downstream curtain walls, bed protection and provision of staggered blocks, if any, should conform to the requirements for falls.

7.3 The regulation arrangements may comprise of flash board (*Karrie*)/ needle regulation or gate regulation or both depending on the importance of the structure.

7.4 The piers and abutments shall have vertical faces without any batter in the portion where gates are provided. A double set of flash board grooves with 30 cm clear space in between shall be provided when flash board regulation is adopted, as shown in Fig. 2. The length of the pier should be checked for safety against sliding for the following conditions:

a) Water headed up to full supply level on upstream and downstream dry.
b) When there is maximum differential head caused by closure of one bay in addition to superimposed loads.

7.5 For gate regulation, a platform generally 1·5 to 2 m wide should be provided for accommodating lifting arrangements as shown in Fig. 2. Also when flash boards are provided, a platform should be provided downstream of the flashboard grooves, as shown in Fig. 2. In case of needle regulation

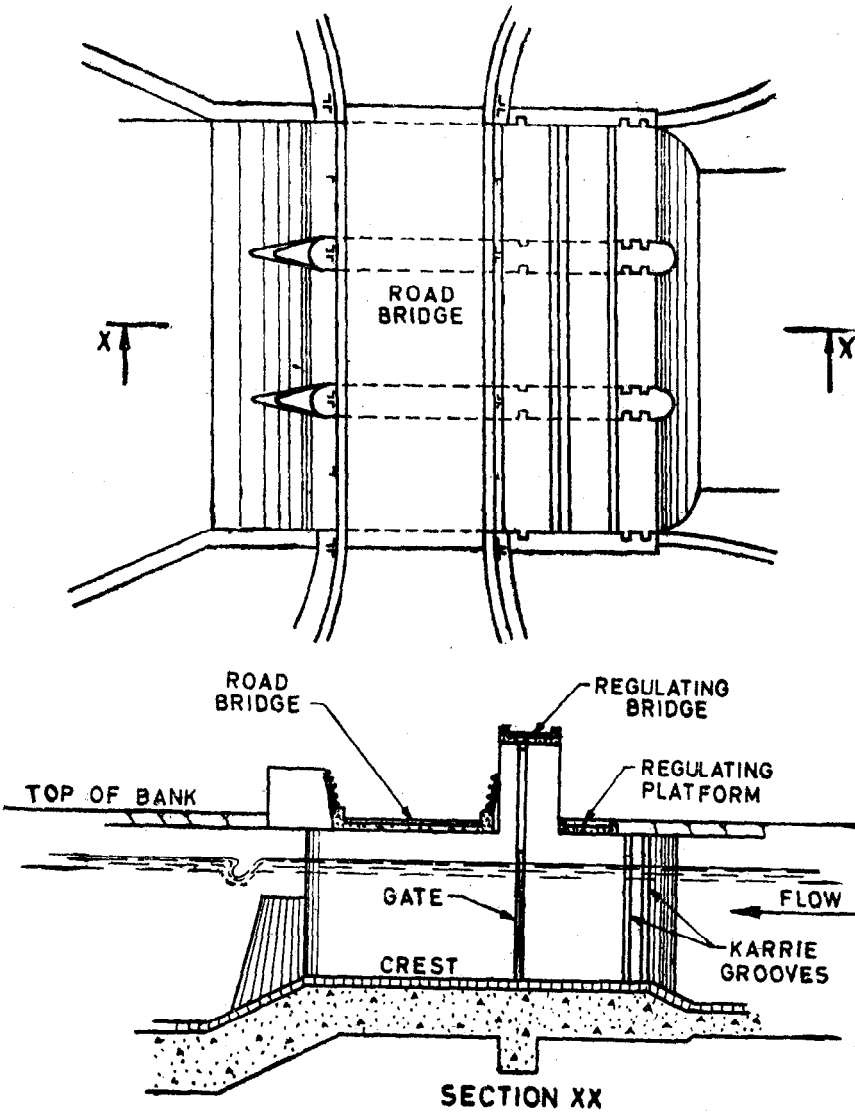

FIG. 2 REGULATOR WITH GATE AND *Karrie* REGULATION

a foot rest for the needle shall be provided on the crest as shown in Fig. 3. The needles should preferably have a slope of 1:5 and the shape of the abutting edge of the regulation platform should be tapered accordingly.

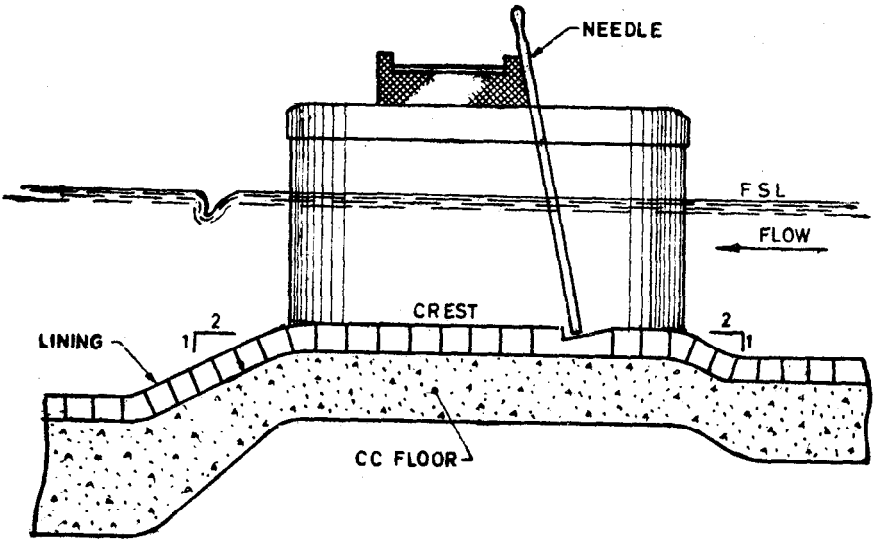

FIG. 3 REGULATOR WITH NEEDLE REGULATION

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